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# **Advanced Design Methodologies for Combat Aircraft**

## **Final Report**

### **Summary**

This is the final report on a two-year assessment from January 1993 to December 1994 of various courses run by the Department of Aeronautics (DFAN) at the United States Air Force Academy (USAFA) in Colorado Springs, USA. The report includes a discussion of: AE215, AE481/2, assessment methods, a forthcoming visit to DFAN in April 1995 and some concluding remarks.

### **Aero Engr 215--Fundamentals of Aeronautics**

This 'introductory' course is an excellent one. DFAN is to be congratulated on tailoring it to suit the requirements of a core course while retaining sufficient rigour for it to be a good prelude to its own specialised courses. Having taught the senior year aircraft design course (AE481/2) I found that I was justifiably able to make many assumptions regarding its students' understanding of basic aerodynamics to which they had been introduced by AE215. The two course directors, Maj. Scott Goodwin and Capt. Mark Beierle, under whom I worked, did a superb job in providing their instructors with all the resources for which I could have wished. In addition, most AE215 instructors brought their own talents and experience to bear and enabled the course to be developed into a fun experience for cadets and faculty alike.

I believe that the: increasing number of and earlier visits to the Aero Lab; the balsa airplane building and flyoff and the recently-introduced 'special' topics all contribute to make the course enjoyable. I hope these will be retained. The increasing incorporation of aspects of aircraft design has been a notable benefit as it helps to motivate the students by allowing them to see the applications of the course topics. I found the Terrazzo tour, coming at the end of the course, very beneficial and, despite the occasionally inclement weather, very much enjoyed by the cadets. This was especially the case if cadets had some prior experience with the four airplanes, which allowed them to help with the description of their design features. I recall learning from one of my cadets the reason for the strakes on the underside of the F-15. The experiment with the AE215Z sections during Fall 1993 and Spring 1994, while not continued, produced some useful data and course material. No doubt there will be further innovations to the course but I can only repeat my congratulations to DFAN on what has already been achieved.

Having returned to Cranfield University at the Royal Military College of Science at Shrivenham, UK, I have been able to reflect on my studies at USAFA and make some valid comparisons (see later). I have been able to put to good use some of the materials which colleagues within DFAN and I developed for AE215. These have proven very useful for a 2nd year course in Aeromechanics which I teach to a class of Royal Air Force students who are reading Electronics Engineering at RMCS. Not surprisingly the course is very similar to AE215 and uses the same text book. The significant differences are that the RMCS course is split 50/50 between aerodynamics and propulsion and the 2nd year does not include any aircraft stability and control nor aircraft performance. These topics are held over to the 3rd (final) year of the course and again is split with propulsion. I am in the fortunate position of teaching both

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courses which will enable me to integrate all the subjects in a much more logical fashion than hitherto.

### **Aero Engr 481/482--Aircraft Design**

The quality of the aircraft design instruction within DFAN is of a very high quality, as are the resources available to the cadets. My overriding concern however remains that cadets do not have enough time to assimilate the fruits of their labors. On numerous occasions I noticed the tendency by the cadets to overlook contradictions with other team members' design decisions. This is hardly surprising and quite forgivable because of the dynamic and ever-changing nature of the process. In addition there is always the danger among faculty, with the involvement in their chosen field, that they forget that their students are not going to become aircraft designers. This is potentially more serious for faculty working within a military institution since their students are even less likely to work on aircraft design than students at civilian schools. I have always held that the nature of design is such that it doesn't really matter what aspects of the subject students are experiencing. It could be automobiles, tanks, missiles, ships. The important thing is that they experience the interaction and integration of the subjects they study, in a creative as well as an analytic way. Nevertheless the experience gained by the cadets of working as a team on an intellectually challenging project is of enormous value.

Although, for administrative reasons, I am not presently involved with the aircraft design course at RMCS I have been visited by several of the students taking the subject seeking advice. In addition I have sat in on one of the teams' presentations and was favourably impressed by the level of competence. This is especially in the case of computer-aided design involving the use of 2- and 3-D modelling and the use of spreadsheets. I think this reflects the increasing emphasis on computer instruction and reduction in costs of PCs and associated software. Much of the commercially-available software which is used at USAFA has been adopted by Cranfield at RMCS. Indeed one student has recently asked for help using the ONX/OFFX engine programs which formed part of the instruction in AE481/482.

A major difference in the running of aircraft design between the two institutions is that at RMCS the lecturing input is minimal. The main emphasis being placed on design team acquiring knowledge and expertise itself. This implies that individual students will only get a sketchy knowledge of the project as a whole since they quickly become 'specialised'. To a degree this is true but the philosophy of the course at RMCS is based more on developing a student's own skills for research which they can then apply to a team effort. The stated aims of the RMCS Aircraft Design Project are:

To provide experience of a major design exercise to promote understanding of interacting requirements.

To provide experience of a group activity, to encourage professionalism and develop leadership qualities.

To develop technical competence by applying academic studies in cross- and multi-disciplinary situations.

To develop communications skills.

The above aims equally well apply to the USAFA effort. However the many differences which exist between education in the US and UK inevitably means that different methods are used to achieve similar goals. This is very healthy and natural.

On my return to the UK I note that there are suggestions that aircraft design courses should be restricted to examination of 'derivative' aircraft. This, for the civil field, suggests the 'stretching' or 'cutting' of an existing design to satisfy a new market requirement. This, it is argued, is what most industrial aircraft designers will do during their careers, given the very long product development cycles which are now commonplace in both the civil and military aircraft fields. The argument has some validity but is to be resisted in my view. What would be lost, and which is so vital for motivation and enjoyment, is the excitement and imagination which is engendered by the 'clean piece of paper' which faces a student commencing on an aircraft design course. Another argument against such a plan for undergraduate study is the difficulty of obtaining enough relevant data on existing designs because of considerations of commercial confidentiality. The 'derivative' design concept may be more appropriate to a graduate level course. This is when career goals are more established in a young person's mind and when a graduate school may have close links with a specific manufacturer.

#### Assessment Methods

The methods used in DFAN to assess their students' understanding and abilities are very professional and more exhaustive than any other comparable institution with I am familiar. To say that they are too exhaustive would imply criticism of DFAN. This is certainly not my intention however I would suggest that a reduction in the time taken for assessment of students may pay dividends in that faculty resources may be put to more beneficial use. I am referring to the time available to faculty for research and further development of the excellent teaching tools which have originated within DFAN. Although some excellent research has been and is currently done in DFAN I was struck by the very tight teaching schedules within which most of the faculty work. With the perceived desire and need for an increased volume of research within DFAN, it may be that reduced efforts on students' assessment, without measurably harmful side-effects, could make a valuable contribution.

As a complete contrast, I have been pleased to learn, on my return to RMCS, that **more** attention is to be given to student assessment than hitherto. It has been of concern to me for many years that insufficient effort has been put into implementing better assessment methods at UK universities. I found this to be especially the case when coming to RMCS nine years ago. At that time around 90 percent of a student's grade was based on the final examinations. This has eased a little over the years; for example the Aircraft Design Project has relied on continuous assessment and other courses have become more coursework-oriented. There is however much more scope to introduce more enlightened ways of assessing a student's ability and understanding. With my experience of USAFA's methods I hope to be of some assistance in this regard at RMCS.

With concerns for quality control in learning it now appears that Cranfield may be moving towards obtaining student feedback on subject and instructor performance via course critiques. Having experienced such a system in the US thirteen years ago I've since thought that such procedures well worth implementing but always met with little enthusiasm from colleagues. The concept within Cranfield is currently being examined but I hope that its introduction isn't long delayed.

### **Brief Visit to DFAN/USAFA in April, 1995**

I will be returning to the Aero Department in April to deliver a Brown Bag on my experiences at USAFA. I hope that I will be able additionally to sit on some of the AE482 classes while I'm there to reacquaint myself with my AE481 cadets with whom it was a pleasure to work.

#### **Overall Impressions**

The main difference I observe between the two institutions (USAFA and RMCS) is the much more rigidly structured regime at USAFA. This is not surprising since USAFA exists to provide military and athletic, as well as academic, instruction. The military experience at RMCS is much more limited. Indeed the military students at RMCS are required on a regular basis to wear uniform only one day per week. Athletic experience is encouraged at RMCS with many well-funded sports clubs and Wednesday afternoons being free from academics. This is the tradition of all UK universities. With the absence of extra-to-academic duties, RMCS students theoretically have more opportunity to reflect on their studies. The evidence to support the actuality of students' reflection is patchy to say the least. It should be noted, however, that young people coming to UK universities will have been fairly well filtered by the national examinations before they are accepted. The percentage of 18 year olds who are qualified to attend UK universities is much lower than in the US.

My experience of working within DFAN was one of continual delight. I found my colleagues to be extremely professional, enthusiastic, and above all, very positive. The opportunities offered me for new experiences of learning and helping were beyond my wildest imagination. I am truly very thankful for the support and encouragement given to me over my two years at USAFA. A large measure of these thanks goes to Col. Mike Smith and Col. Randy Stiles.

Ray Whitford  
Principal Investigator  
March 1995